THE MEASUREMENT OF DIFFUSION CONSTANTS OF GASES

BY
GLENN ANSEL KIDDER
A.B., University of Illinois, 1939

AN ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
CHEMISTRY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1943

URBANA, ILLINOIS
1943

THE MEASUREMENT OF DIFFUSION CONSTANTS OF GASES

BY
GLENN ANSEL KIDDER
A.B., University of Illinois, 1939

AN ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
CHEMISTRY IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1943

URBANA, ILLINOIS
1943

ACKNOWLEDGMENT

The author wishes to express his appreciation to Professor F. T. Wall under whose supervision this investigation was made.

THE MEASUREMENT OF DIFFUSION CONSTANTS OF GASES

Graham's work[1] between 1829 and 1863 gave the first accurate picture of the gaseous diffusion process. His conclusion that the relative velocities were inversely proportional to the square roots of the densities, still stands as an important generalization and still bears his name. Lochschmidt[2] in 1870 was the first investigator to use the exact mathematical theory of diffusion in a long tube to obtain accurate diffusion constants. Since 1870 many investigators have used methods similar to that devised by Lochschmidt to measure diffusion constants, among them, Obermayer[3], Schmidt[4], Jackman[5], Deutsch[6], Lonius[7], Mackenzie and Mellville[8], Boardman and Wild[9], and Heath, Ibbs and Wild[10].

The work of Boardman and Wild[9] is of particular interest because they measured the diffusion constant for the pair CO_2-N_2O and assumed that due to the similarity of the two gases this value might be taken as the self diffusion constant for either gas.

Method

The apparatus described by Boardman and Wild[9] was improved by the addition of water jackets for the diffusion tubes and a system of stops to facilitate operation. It consists of two tubes of the same uniform internal diameters and the same internal lengths, set in circular brass plates which had been ground together. The plates can be rotated so that the diffusion tubes are directly over each other, shut completely off, or connected with the rest of the system for filling and analysis. The procedure is to fill each tube with a pure gas at atmospheric pressure, then rotate the plates so that one tube is directly over the other for a measured length of time. At the end of this time the tubes are shut off by rotating the plates and the gas mixture in each tube is analyzed. From these analyses and the time of diffusion the diffusion constant for the pair can be calculated.

Results

Using the method outlined the following results were obtained. All results are corrected to 760 mm. and 298°C.

Gas Pair	D_{12}
CO_2-N_2O	0.1170 cm.^{2}/sec.
CO_2-C_3H_8	0.0863
N_2O-C_3H_8	0.0860
CO_2-C_2H_4O	0.0918
N_2O-C_2H_4O	0.0914

The results for the two pairs containing C_2H_4O are not considered as reliable due to the difficulty of working with this gas.

From these results, using formulas developed by Chapman and Cowling,[1] mean molecular diameters, molecular diameters, and self diffusion coefficients were calculated. The molecular volume of C_3H_8 was calculated and compared with those of H_2, CH_4, C_2H_4. It was found that when the molecular volumes of these compounds were plotted against the number of carbon atoms, a straight line was obtained. The value for H_2, CH_4, and C_2H_4 were calculated from diffusion data in Chapman and Cowling[1]. The value for C_2H_4 was used as no data was available for C_2H_6.

Bibliography

1. Chapman, S. and Cowling, T. G., "The Mathematical Theory of Non-uniform Gases" Cambridge University Press, 1939.
2. Loschmidt, Wien. Sitz., **61**, 367,(1870); **62**, 468,(1870).
3. Obermayer, S. B. Akad. Wiss. Wien., **81**, 1102,(1880).
4. Schmidt, Ann. d. Physik, **14**, 801,(1904).
5. Jackmann, Inaug. Diss Halle, (1906).
6. Deutsch, Ibid., (1907).
7. Lonius, Ann. d. Physik, **29**, 664,(1929).
8. McKenzie and Melville, Proc. Roy. Soc. Edinburg, **52**, 337,(1932); **53**, 255,(1933).
9. Boardman and Wilde, Proc. Roy Soc., A **162**, 511,(1937).
10. Heath, Ibbs, and Wild, Proc. Roy. Soc., A **178**, 380,(1941).

VITA

The author was born in Peoria, Illinois on February 11, 1915. He attended the elementry schools of that city and in 1932 graduated from the Peoria Central High School. In the Fall of 1943 he entered Illinois State Normal University at Normal, Illinois. He attended there until the Spring of 1938 with the exception of the Fall semester of 1937-38, which was spent at Bradley College, Peoria, Illinois. In the Fall of 1938 he entered the University of Illinois where he received the A.B. degree in the Spring of 1939. In the Fall of 1939 he entered the Graduate School of the University of Illinois. He has been a graduate assistant on the staff in physical chemistry at the University of Illinois since September 1940. He is a member of Sigma Xi.

Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41549818_0190